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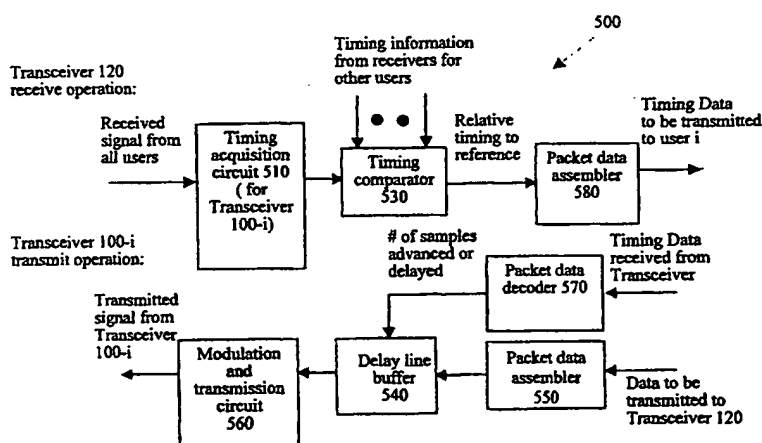
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(54) Title: **METHOD AND APPARATUS FOR TIMING CONTROL IN DIGITAL COMMUNICATION SYSTEMS**



(57) Abstract: The present invention provides an apparatus and method for detecting the relative time of arrival of different signals at a single receiver from different respective transmitters, and causing the different respective transmitters to alter the time that they transmit their signals so that the time of arrival of signals from different transmitters is within a predetermined period. The present invention uses either a closed loop timing control, a GPS based timing control, or an open loop based timing control, to determine the time that signals from different transmitters need to be altered in order to obtain time of arrival for different signals within the predetermined period. As a result of the arriving signals being "semi-synchronous", any detection algorithms taking advantage of time synchronism, for example multi-user detection or interference rejection, can be much more effective in signal detection for the data transmitted from multiple transmitters to a single receiver.

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## METHOD AND APPARATUS FOR TIMING CONTROL IN DIGITAL COMMUNICATION SYSTEMS

Field of the Invention

5       The present invention relates to a method and apparatus for closed loop and open loop timing control for digital communication systems.

Background of the Related Art

Synchronous and asynchronous packet based communications systems are well known.

10       In a synchronous packet based communication system, packet transmissions must be synchronized so that packets are received by the receiver with a time of arrival that falls within a narrow predetermined detection window. If a packet is transmitted such that it is not received within the predetermined detection window, the receiver will not detect it.

15       In contrast, asynchronous packet based communications systems do not require synchronization of the time of arrival with a narrow predetermined window, but instead typically require either a much longer detection window in order to detect the incoming asynchronous communication or simply limit the number of users, or a dynamic allocation of packets to different users. Each of these solutions, however, have either reduced capacity or increased complexity and are not, therefore, considered as effective in many circumstances.

20       In part due to the above considerations, conventional communications systems will use both synchronous and asynchronous communications. For example, in a communication system based upon the IS-95 standard, communications in the forward link, from the base station to each of a large number of different users having a receiver, are synchronous. Communications in the reverse link, from each of the different users back to the base station, however, are performed asynchronously.

25       This scheme is used since in the forward link, signals intended for different users from the base-station are by definition synchronous, as the data for multiple users are processed and transmitted synchronously. Therefore, signal detection is effective in combating interference in the forward link, where the receiver is located at the user's side. The reverse link, however, does not provide a convenient timing reference. Since the signals from the multiple  
30       users cannot be conveniently synchronized due to propagation delays, timing synchronization amongst the users has not been attempted in traditional CDMA systems. Strategies such as error-correcting coding and closed loop power control are used in the reverse link of traditional CDMA systems, such as in IS-95, to insure that the detection of the signal from an intended user is not degraded by the interference generated by other users. The timing of

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signal arrivals from multiple users is, therefore, not a major concern in such a traditional CDMA system because interfering signals are treated as noise at the receiver.

Since timing control is not attempted in asynchronous environments, such as the reverse link of an IS-95 compliant communication system, the signals from multiple users arrive at random times and the interference rejection capabilities become reduced. Accordingly, asynchronous interference rejection is considered difficult and infeasible in an environment requiring higher capacity.

#### SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to obtain semi-synchronous communications in order to improve signal detection capabilities.

It is another object of the invention to implement a multi-user detection scheme that uses timing control in order to increase the overall capacity of the system.

It is another object to implement an orthogonal-frequency division multiplexing scheme that allows multiple data streams to be transmitted by different users at the same time.

In order to attain the above objects of the present invention, among others, the present invention provides an apparatus and method for detecting the relative time of arrival of different signals at a single receiver from different respective transmitters, and causing the different respective transmitters to alter the time that they transmit their signals so that the time of arrival of signals from different transmitters is within a predetermined period.

The present invention uses either a closed loop timing control, a GPS based timing control, or an open loop based timing control, to determine the time that signals from different transmitters needs to be altered in order to obtain time of arrival for different signals within the predetermined period.

As a result of the arriving signals being "semi-synchronous," any detection algorithms requiring time synchronism, for example multi-user detection, can be much more effective in interference rejection for the data transmitted from multiple transmitters to a single receiver.

This invention can be applied to many different types of communications systems, and has particular applicability to code division multiple access (CDMA) systems, which CDMA systems may or may not use multi-user detection schemes in which interference rejection can then be more effective. This invention can also be applied to multiple antenna systems, where the timing of signal arrivals from multiple antennas (either from a single transmitter or from multiple transmitters) is also of importance.

Still further, the present invention can be applied to orthogonal frequency division multiplexing (OFDM) systems where multiple users transmit data at the same time, which require precise timing control at the receiver. Furthermore, the present invention has applicability to time division multiple access (TDMA) systems that require precise timing control.

### BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features, and advantages of the present invention are further described in the detailed description which follows, with reference to the drawings by way of non-limiting exemplary embodiments of the invention, wherein like reference numerals represent similar parts of the present invention throughout several views and wherein:

Fig. 1 illustrates an overview of a multi-user system according to the invention;

Fig. 2 illustrates the relative time of arrival of the first sample of arbitrary packets from different transmitters at a receiver prior to application of timing control according to the invention;

Fig. 3 illustrates the relative time of arrival of the first sample of arbitrary packets from different transmitters at a receiver after application of timing control according to the invention;

Fig. 4 further illustrates the definitions of delay and advance from a design point of view;

Fig. 5 illustrates a block diagram of a circuit for implementing closed loop timing control according to a preferred embodiment of the invention;

Fig. 6 illustrates a block diagram of a circuit for implementing open loop timing control according to a preferred embodiment of the invention; and

Fig. 7 illustrates an example of multiple base-stations each with multiple end-users.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention implements timing control so that signals from a plurality of transceivers 100-1, 100-2, 100-3...100-n have a semi-synchronous time of arrival with respect to each other at a transceiver 120, such as illustrated in Fig. 1. While not limited to the specific embodiment, the following discussion will be made with reference to a CDMA system that employs multi-user detection in the reverse link.

One aspect of the invention will become apparent with reference to Figs. 2 and 3. Prior to implementing the timing control of the present invention, the relative time of arrival of

arbitrary packets from different transmitters at a receiver is asynchronous. As illustrated in Fig. 2, from a reference timing point 210, signal 100-1 lags by about 7 samples, signal 100-2 lags by about 10 samples, signal 100-3 is advanced by about 8 samples, and signal 100-4 lags by about 5 samples. Packets, which contain data and/or control information relating to the communications, from each of these users, are assumed to repeat at relatively consistent intervals so that each user can continue to communicate during a communication session. It should be noted that consistent interval is not intended to mean synchronous or asynchronous, but only a repetition of consecutive packets such that communications can continue within the system. The present invention manipulates the time that these signals are transmitted, so that their time of arrival at the receiver becomes semi-synchronous. Thus, as illustrated in Fig. 3, by advancing signal 100-1 by 7 samples, advancing signal 100-2 by 10 samples, delaying signal 100-3 by 8 samples, and advancing signal 100-4 by 5 samples, signals 100-1 to 100-4 become semi-synchronous with respect to the reference timing point 210.

To further describe one implementation of an advance or a delay of time, Fig. 4 illustrates the sequence of events as a function of time. Assume that at time T1, transmitter 100-i starts the computation in preparation for the transmission of the next packet. At time T2, the computation is completed and transmission starts. The time between T2 and T1 is called the computation latency. The delay and advance can be implemented by a delay line buffer, which holds the data to be transmitted in an array of pipeline registers. If the reference time is to be in between T2 and T3, as illustrated in Fig. 4, the buffer is about half deep, which means that the transmitted data would be delayed by  $(T3-T2)/2$  seconds. When the base station informs this transmitter to either delay or advance the transmission of the next packet, the depth of the delay line buffer is adjusted accordingly. The number of the pipeline registers that implement the delay line buffer is bounded by the maximum propagation delay between all the end-user transceivers to the base station. It should be understood that other manners of implementing the advance or delay could be used.

Fig. 5 illustrates a block diagram of a circuit 500 for implementing timing control according to a preferred embodiment of the present invention. As will be apparent, this Figure illustrates those circuits within the end-user transceiver (such as 100-i), as well as within a base station transceiver 120 that are needed to implement the present invention. Other parts of receivers, transmitters or transceivers can be made using conventional techniques and methods, and will therefore not be further discussed. As illustrated, at the base station transceiver 120, the precise timing of each user (such as transceiver 100-i) relative to a reference time point is extracted by a timing acquisition circuit 510 dedicated to

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that user. A timing comparator 530 gathers the timing information from each timing acquisition circuit 510 and performs time alignment in order to determine the advance or delay of the packets to be transmitted by that user's transceiver. The information on the amount of advance or delay that needs to be inserted by that particular transceiver 100-i, which is performed separately for each individual user, is sent to that user as a timing control signal that is part of the data packet, which packet is assembled in the transceiver 120 using a conventional data packet assembler 580. This information, once received and decoded by the data packet decoder 570 associated with the transceiver 100-i of the intended user is used to control a delay line buffer 540, which receives the data packet to be transmitted to the transceiver 120 from its own data packet assembler 550 before transmitting the next packet to the transceiver. This procedure can be repeated at each packet to further refine the accuracy of the timing control. This timing control procedure can also be exercised occasionally, at predetermined intervals, or once every several packets, depending on the relative dynamics of the base-station and individual end-user transceivers. Alternatively, an updated timing control signal is retransmitted when the timing comparator 530 determines that the time-alignment has changed a predetermined amount, such that the time-alignment is no longer within a predetermined range.

Since the timing acquisition function at the receiver is necessary to determine the precise sampling phase of the incoming signal for signal detection, the extraction of the timing control signal from the incoming signal is relatively easily implemented by the timing extraction circuit, which extracts the timing information using conventional timing acquisition techniques, such as those proposed in H. Meyr, M. Moeneclaey, and S. Fechtel, Chapters 5 & 10, *Digital Communication Receivers*, John Wiley and Sons, 1998, New York; K. H. Mueller and H. Muller, "Timing recovery in digital synchronous data receivers," *IEEE Trans. Communications*, Vol. COM-24, pp. 516-531, May 1976; and B. Sklar, Chapter 8, *Digital Communications: Fundamentals and Applications*, Prentice Hall, 1988, New Jersey. Of conventional techniques, the delay-lock-loop technique is most commonly used for timing extraction. The accuracy of closed-loop timing control implemented by the circuit 500 should preferably be within a fractional of a sample period, or at most a couple of sample periods, in order to provide for effective interference rejection in a CDMA system or concurrent multi-carrier signal detection in an OFDM system. If the timing control does not align all packets from the various users to within a few sample periods, then the effectiveness that the present invention is able to have will become substantially reduced. For example, the multi-user detection algorithms, such as described in Sergio Verdu, *Multiuser Detection*, Cambridge

University Press, 1998, when applied to asynchronous channels either demand a lot more computation, or suffer from a reduction in overall channel capacity. This invention either relaxes the computation requirement in performing such algorithms for asynchronous channels, or increases the achievable system capacity by allowing more users to be transmitting at the same time.

Fig. 6 illustrates a block diagram of a circuit 600 for implementing open loop timing control according to a preferred embodiment of the present invention. As will be apparent, this Figure illustrates those circuits within the end-user transceiver (such as 100-i). In contrast to the circuits required by the closed loop timing control of Fig. 5, the present invention can be implemented by making adaptations to end-user transceivers, without significantly affecting the design and operation of the base station transceiver 120. As in the discussion of the closed loop timing control system provided above, other parts of receivers, transmitters or transceivers not mentioned herein can be made using conventional techniques and methods, and will therefore not be further discussed.

As illustrated, each transceiver 100-i to 100-n associated with each user keeps a time reference synchronized with base station transceiver 120. This time synchronization within each transceiver 100-i to 100-n is maintained by either a GPS or through other means of global synchronization mechanism. The timing information of the received forward link signal is extracted by the timing acquisition circuit 610, which can be the same as the timing acquisition circuit 510 associated with a single user device as previously discussed, except the timing acquisition circuit 610 is, in this described implementation of this embodiment, part of each transceiver 100 rather than part of the base station transceiver 120. This timing information is compared with the time when the data should have been transmitted by transceiver 120 using comparator 630. The time when the data should have been transmitted is pre-determined and known locally using a GPS or a globally synchronized timing device 620. The difference is calculated and serves as an estimate of the propagation delay between transceiver 120 and transceiver 100-i. This propagation delay estimation is used to control the delay line buffer 640 at the transmitter and therefore align the reverse link signal that has been assembled by the data packet assembler 650 with those from other users as received by transceiver 120. The delay line buffer 640 and the data packet assembler 650 correspond to the delay line buffer 540 and the data packet assembler 550, respectively, that were previously discussed. This procedure can be repeated at each packet to further refine the accuracy of the timing control. The open loop timing control procedure can also be exercised

occasionally, or once every several packets, depending on the relative dynamics of the base-station and individual transceivers.

The accuracy of open loop timing control implemented by the circuit 600 is a function of the channel multipath profile and the mobility of the users. Assuming that the delay spread of the channel is relatively short compared to the required length of coherence for detection, the open loop timing control according to the invention can synchronize the incoming signals to within a fractional of one data symbol period (on the same order of the delay spread). It is noted that open loop timing control is typically not as precise as closed-loop timing control, since the uncertainty in multi-path channel is larger than the uncertainty of the timing acquisition circuit at the receiver. The uncertainty in the timing can, therefore, be viewed as a form of multipath. Since a properly designed multi-user detection system should perform well in the face of multipath in the forward link, the semi-synchronous reception as enabled by the present invention allows the system to deliver similar performance in the reverse link.

A specific example implementing the present invention using the system described above is the use of timing control in a CDMA system that employs multi-user detection. It is known how to perform interference rejection on asynchronous channels in a reverse link, but conventional interference rejection techniques are not used on time-aligned signals. The application of the present invention in such systems allows all reverse link signals to become semi-synchronous, thereby simplifying the asynchronous detection algorithm to a synchronous detection algorithm. Of the conventional interference rejection techniques, the adaptive multi-user detection technique described in M. Honig, U. Madhow, and S. Verdu, "Blind Adaptive Multiuser Detection," *IEEE Trans. on Information Theory*, pp. 944-961, Vol. 41, No. 4, July 1995 is most preferred because it decouples the detection of any single channel from that of the other channels.

Another preferred implementation is the use of timing control in an OFDM system that allows multiple end-users to transmit data at the same time. In a conventional OFDM system, such as disclosed in B. Le Floch, M. Alard, and C. Berrow, "Coded Orthogonal Frequency Division Multiplex," *Proceedings of IEEE*, pp. 982-996, Vol. 83, No. 6, June 1995, the input data undergoes an inverse-fast-Fourier-transform (IFFT) before being transmitted. In other words, data are encoded on multiple carrier frequencies. The receiver performs a fast-Fourier-transform (FFT) before signal detection at each carrier frequency. Since the IFFT and FFT have to be performed on all data to be transmitted or received, multiple access to multiple users has traditionally been provided for by way of time-division-multiple-access (TDMA), in which each user is assigned a time slot to transmit its data and



no two users can transmit their data at the same time. The present invention allows multiple users in an OFDM system to transmit data at the same time because the signals transmitted from different users can be time-aligned at the receiver, as long as these users use different carrier frequencies in their transmission. Since the signals from different users are time-aligned, FFT can be performed on the received signal without destroying the coherent properties of the transmitted data.

It should be noted that the present invention provides a method such that signals transmitted from the transceivers 100 typically arrive at the base station transceiver 120 within a predetermined period of time, such as a few sample periods. However, the present invention can still be utilized if only substantially all, or any portion, of the signals arrive within the predetermined period. In that event, however, the overall signal detection capability may be degraded as compared to the case where all signals are time-aligned, but partially aligned systems should still perform better than those without using the present invention.

According to the present invention, once the incoming signals are approximately aligned, any detection scheme that takes advantage of synchronous reception, for example CDMA, multi-user detection, smart antenna, multiple antenna systems, TDMA, or multi-user OFDM, can benefit from this invention.

The present invention can also be applied to a communication system where multiple base-stations are deployed, such as used in the cellular phone system. The relative timing information of the multiple transceivers detected by each base-station can be communicated to other base-stations. The exact amount of time advance or delay that should be exercised by each transceiver can be negotiated amongst the base-stations. for the purpose of achieving the best overall system performance. For example, assume that there are two base-stations with their perspective end-users transceivers, as illustrated in Fig. 7. Base-station 710 performs timing control to its end-users transceivers 710-i and base-station 720 performs timing control to its end-users transceivers 720-i. Since transceiver 720-1 is closer to base-station 710 than to base-station 720, it may be more advantageous for transceiver 720-1 to be time-aligned with the reception of base-station 710, rather than to be time aligned with the reception of base-station 720. Since, for the above example, the transceiver 720-1 is closer to base-station 710, if it is time-aligned with base-station 710 then the interference that it may otherwise be creating for base-station 710 can be removed. Although transceiver 720-1 will not necessarily be time aligned with base station 720, although it will be communicating with it, the overall system performance will be improved, since the removal of a significant

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interferor with respect to base station 710 will have a greater impact than a time aligned transceiver that is distant from base station 720. The above example is provided with respect to two base stations, but the present invention contemplates that three, four or more base stations may need to be in communication with each other in order to determine the station with which the particular transceiver is time aligned. Further, such time alignment may be performed for reasons other than interference removal.

While the present invention has been described herein with reference to particular embodiments thereof, a latitude of modification, various changes and substitutions are intended in the foregoing disclosure, and it will be appreciated that in some instances some features of the invention will be employed without a corresponding use of other features without departing from the spirit and scope of the invention as set forth in the appended claims.

I claim:

1. A method of providing a time aligning control signal to each of a plurality of transceivers that repeatedly transmit signals to a common transceiver comprising the steps of:  
detecting the time of arrival at the common transceiver of one signal transmitted from each of the plurality of transceivers;  
determining, for each transceiver, an advance or delay of a subsequent signal to be transmitted to the common transceiver so that the subsequently transmitted signal from each of the plurality of transceivers has a time of arrival substantially within a predetermined period; and  
transmitting from the common transceiver to each of the plurality of transceivers a timing control signal that includes an amount of advance or delay for the respective transceiver so that the subsequently transmitted signal from substantially all of the transceivers will be advanced or delayed an amount determined by the advance or delay within the timing control signal.
2. A method according to claim 1 wherein the steps of detecting, determining and transmitting are repeated for each of the plurality of transceivers during a communication session that each transceiver has with the common transceiver.
3. A method according to claim 1 wherein the steps of detecting, determining and transmitting are repeated at predetermined intervals for each of the plurality of transceivers during a communication session that each transceiver has with the common transceiver.
4. A method according to claim 1 wherein the steps of detecting, determining and transmitting are repeated for each of the plurality of transceivers during a communication session that each transceiver has with the common transceiver when the time-alignment of the respective transceiver is no longer within a predetermined range.
5. A method according to claim 1 wherein the greatest amount of advance is less than the computational latency.
6. A method according to claim 1 wherein the step of detecting the time of arrival includes the step of extracting timing information.

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7. A method according to claim 6 wherein the step of extracting timing information uses a delay-lock-loop technique.

8. A method according to claim 6 wherein the step of determining includes the steps of gathering the timing information and performing time alignment.

9. A method according to claim 1 further including the step of performing interference rejection at the common transceiver on at least certain subsequent signals transmitted from each of the plurality of transceivers to the common transceiver.

10. A method according to claim 1 wherein there exists a second plurality of transceivers that repeatedly transmit second signals to the common transceiver, and wherein there is not determined an advance or delay of subsequent second signals for each of the second plurality of transceivers.

11. A method of providing a time aligning control signal to each of a plurality of transceivers that repeatedly transmit signals to a common transceiver comprising the steps of:

detecting the time of arrival at the common transceiver of one signal transmitted from each of the plurality of transceivers;

determining, for each transceiver, an advance or delay of a subsequent signal to be transmitted to the common transceiver

transmitting from the common transceiver, for each of the plurality of transceivers, a timing control signal that includes an amount of advance or delay;

receiving the timing control signal at each of the plurality of transceivers;

extracting the timing control signal at each of the plurality of transceivers; and

using the advance or delay contained in the extracted timing control signal to correspondingly advance or delay a subsequently transmitted signal from each of the plurality of transceivers so that the subsequently transmitted signal from substantially all of the plurality of transceivers has a time of arrival at the common transceiver substantially within a predetermined period.

12. A method according to claim 11 further including the steps of:

receiving the subsequently transmitted signal from each of the plurality of receivers that arrive at the common transceiver substantially within the predetermined period.

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13. A method according to claim 12, further including the step of performing interference rejection on at least certain ones of the subsequently transmitted signals from the plurality of transceivers that arrive at the common transceiver within the predetermined range.

14. A method according to claim 13 wherein the steps of detecting, determining, transmitting, receiving, extracting, using, and receiving are repeated until a communication session between any one of the transceivers and the common transceiver ends.

15. A method according to claim 14 wherein the steps of detecting, determining, transmitting, receiving, extracting, using, and receiving continue to repeat for all other transceivers when the communication session between the one of the transceivers and the common transceiver ends.

16. A method according to claim 14 wherein the repeating occurs at predetermined intervals.

17. A method according to claim 11 wherein the repeating occurs when the time-alignment of the respective transceiver is no longer within a predetermined range.

18. A method according to claim 11 wherein the greatest amount of advance is less than the computational latency.

19. A method according to claim 11 wherein the step of detecting the time of arrival includes the step of extracting timing information.

20. A method according to claim 19 wherein the step of extracting timing information uses a delay-lock-loop technique.

21. A method according to claim 19 wherein the step of determining includes the steps of gathering the timing information and performing time alignment.

22. A method according to claim 11 wherein there exists a second plurality of transceivers that repeatedly transmit second signals to the common transceiver, and wherein there is not determined and advance or delay of subsequent second signals for each of the second plurality of transceivers.

23. A method of time aligning signals from each of a plurality of transceivers that repeatedly transmit reverse link signals to a common transceiver and receive transmitted forward link signals from the common transceiver comprising the steps of:

receiving forward link signals at each of the plurality of transceivers transmitted from the common receiver, one forward link signal being received at each of the plurality of transceivers;

detecting, at each of the plurality of transceivers, the time of arrival of the one forward link signal transmitted from the common transceiver;

determining, at and for each transceiver, an advance or delay of a subsequent reverse link signal to be transmitted to the common transceiver; and

transmitting the subsequent signal from each of the plurality of transceivers using the respective advance or delay so that the subsequent signal transmitted by substantially all of the plurality of transceivers has a time of arrival at the common transceiver substantially within a predetermined period.

24. A method according to claim 23 further comprising the steps of receiving each of the subsequent signals at the common transceiver; and performing interference rejection on subsequent signals received substantially within the predetermined period.

25. A method according to claim 23 wherein the steps of detecting, determining, transmitting, receiving, extracting, using, and receiving are repeated until a communication session between any one of the transceivers and the common transceiver ends.

26. A method according to claim 25 wherein the steps of detecting, determining, transmitting, receiving, extracting, using, and receiving continue to repeat for all other transceivers when the communication session between the one of the transceivers and the common transceiver ends.

27. A method according to claim 25 wherein the repeating occurs at predetermined intervals.

28. A method according to claim 23 wherein the repeating occurs when the time-alignment of the respective transceiver is no longer within a predetermined range.

29. A method according to claim 23 wherein the greatest amount of advance is less than the computational latency.

30. A method according to claim 23 wherein the step of detecting the time of arrival includes the step of extracting timing information.

31. A method according to claim 30 wherein the step of extracting timing information uses a delay-lock-loop technique.

32. A method according to claim 30 wherein the step of determining includes the steps of gathering the timing information and performing time alignment.

33. A method according to claim 23 wherein there exists a second plurality of transceivers that repeatedly transmit second signals to the common transceiver, and wherein there is not determined an advance or delay of subsequent second signals for each of the second plurality of transceivers.

34. A common transceiver apparatus for providing a time aligning control signal to each of a plurality of transceivers that repeatedly transmit signals to the common transceiver comprising:

means for detecting the time of arrival at the common transceiver of one signal transmitted from each of the plurality of transceivers;

means for determining, for each transceiver, an advance or delay of a subsequent signal to be transmitted to the common transceiver so that the subsequent signal transmitted from each of the plurality of transceivers has a time of arrival substantially within a predetermined period; and

means for transmitting from the common transceiver to each of the plurality of transceivers a timing control signal that includes the advance or delay for the respective transceiver so that a subsequently transmitted signal from substantially all of the transceivers

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will be advanced or delayed an amount determined by the advance or delay within the timing control signal.

35. An apparatus according to claim 34 wherein the means for transmitting includes a delay line.

36. An apparatus according to claim 35 wherein the greatest amount of advance in the delay line is less than the computational latency.

37. An apparatus according to claim 34 wherein the means for determining includes a timing comparator.

38. A transceiver that is capable of time aligning signals with other signals from other transceivers that are all repeatedly transmitting reverse link signals to a common transceiver and receive transmitted forward link signals from the common transceiver comprising:

means for receiving one of the forward link signals transmitted from the common receiver;

means for detecting the time of arrival of the one forward link signal transmitted from the common transceiver;

means for determining an advance or delay of a subsequent reverse link signal to be transmitted to the common transceiver; and

means for transmitting the subsequent signal using the respective advance or delay so that the subsequent signal transmitted has a time of arrival at the common transceiver substantially within a predetermined period.

39. An apparatus according to claim 38 wherein the means for transmitting includes a delay line.

40. An apparatus according to claim 39 wherein the greatest amount of advance in the delay line is less than the computational latency.

41. An apparatus according to claim 38 wherein the means for determining includes a timing comparator.



42. A method of providing a time aligning control signal to each of at least first and second plurality of transceivers that repeatedly transmit signals to respective at least first and second common transceivers comprising the steps of:

detecting the time of arrival at the respective first and second common transceiver of one signal transmitted from each of the respective first and second plurality of transceivers;

determining, for each transceiver, an advance or delay of a subsequent signal to be transmitted to the common transceiver so that the subsequent signal transmitted from substantially all of the first and second plurality of transceivers has a time of arrival substantially within a predetermined period, wherein the time of arrival for certain ones of the subsequent signals is based upon the time of arrival of the subsequent signal at the first and second common transceiver which receives the subsequent signal so that a communication session can continue and the time of arrival for at least one of the subsequent signals communicating with the first common transceiver is based upon the time of arrival of the one subsequent signal at the second common transceiver with which it is not communicating; and

transmitting from the first and second common transceiver to each of the respective first and second plurality of transceivers a timing control signal that includes an amount of advance or delay for the respective transceiver so that a subsequently transmitted signal from each of the transceivers will be advanced or delayed an amount determined by the advance or delay within the timing control signal.

43. A method according to claim 42 further including the step of performing interference rejection at the second common transceiver on the one subsequent signal.

44. A method according to claim 42 wherein there is included a third plurality of transceivers that repeatedly transmit signals to a third common transceiver, and wherein:

the step of detecting detects the time of arrival at the third common transceiver of one signal transmitted from each of the third plurality of transceivers;

the step of determining determines, for each transceiver, the advance or delay of a subsequent signal to be transmitted to the common transceiver so that the subsequent signal transmitted from substantially all of the first, second and third plurality of transceivers has a time of arrival substantially within a predetermined period, wherein the time of arrival for certain ones of the subsequent signals is based upon the time of arrival of the subsequent signal at the first, second and third common transceiver which receives the subsequent signal so that a communication session can continue and the time of arrival for at least one of the

subsequent signals communicating with the first common transceiver is based upon the time of arrival of the one subsequent signal at the second common transceiver with which it is not communicating and the time of arrival for at least another one of the subsequent signals communicating with the first common transceiver is based upon the time of arrival of the another one subsequent signal at the third common transceiver with which it is not communicating; and

the step of transmitting transmits from the first, second and third common transceiver to each of the respective first, second and third plurality of transceivers a timing control signal that includes an amount of advance or delay for the respective transceiver so that a subsequently transmitted signal from each of the transceivers will be advanced or delayed an amount determined by the advance or delay within the timing control signal.

45. A method according to claim 1 wherein the step of transmitting transmits each timing signal at a carrier frequency.

46. A method according to claim 11 wherein each one signal and each subsequently transmitted signal are transmitted at a carrier frequency.

47. A method according to claim 11 wherein the subsequent signal transmitted from respective transceivers are each transmitted at a carrier frequency.

48. An apparatus according to claim 34 wherein the means for transmitting transmits each timing signal at a carrier frequency.

49. An apparatus according to claim 34 wherein the means for transmitting transmits each subsequent signal at a carrier frequency.

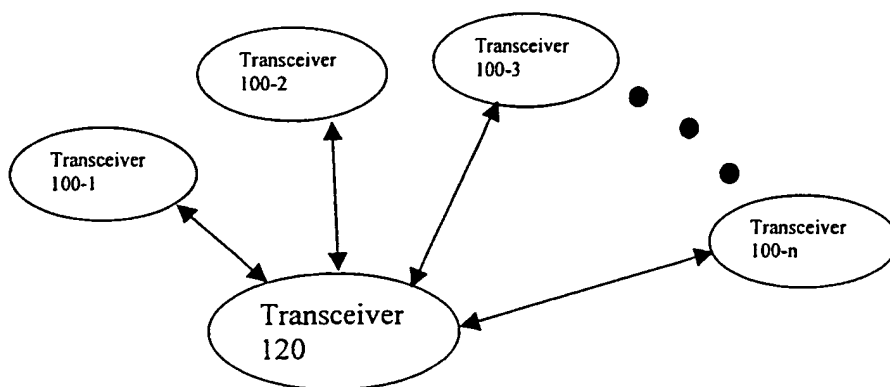


Figure 1

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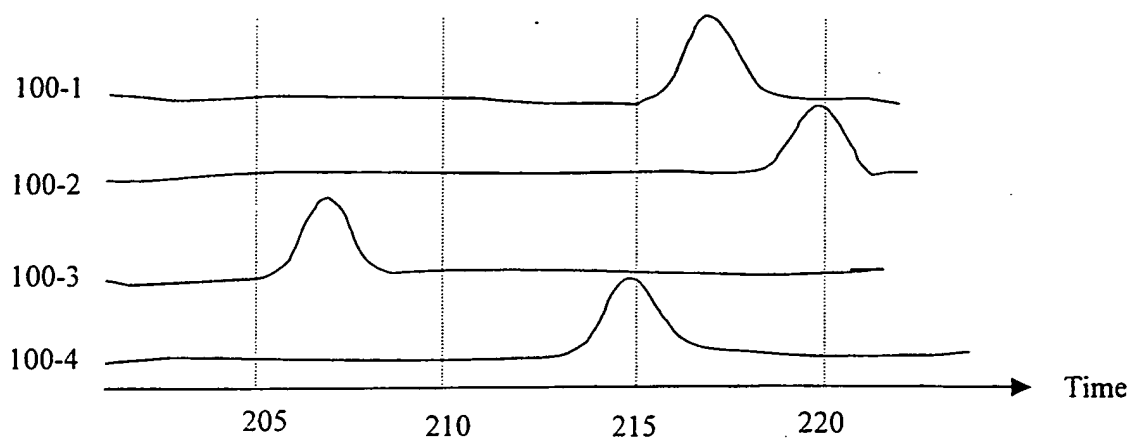


Figure 2

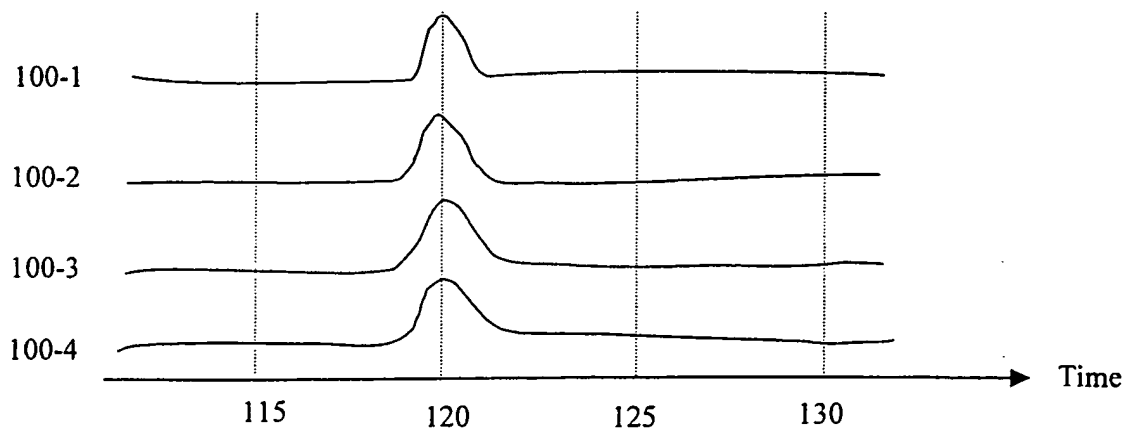


Figure 3

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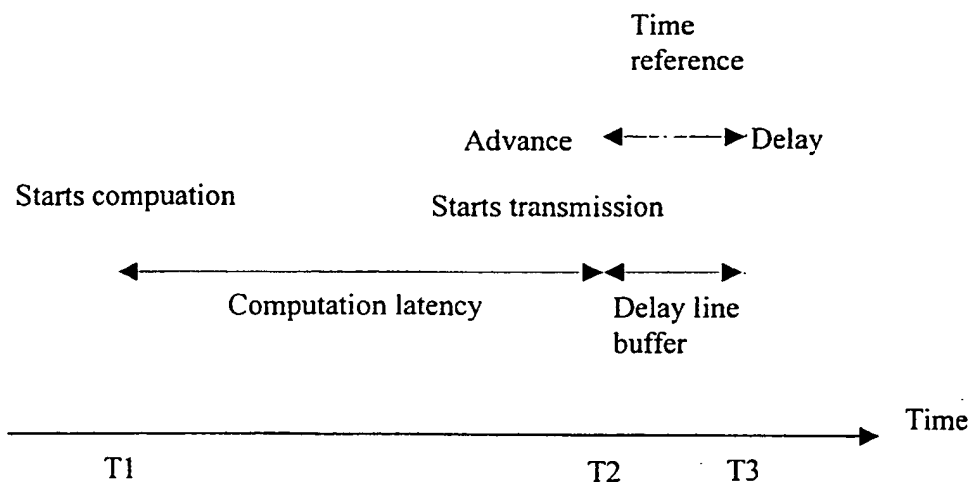


Figure 4

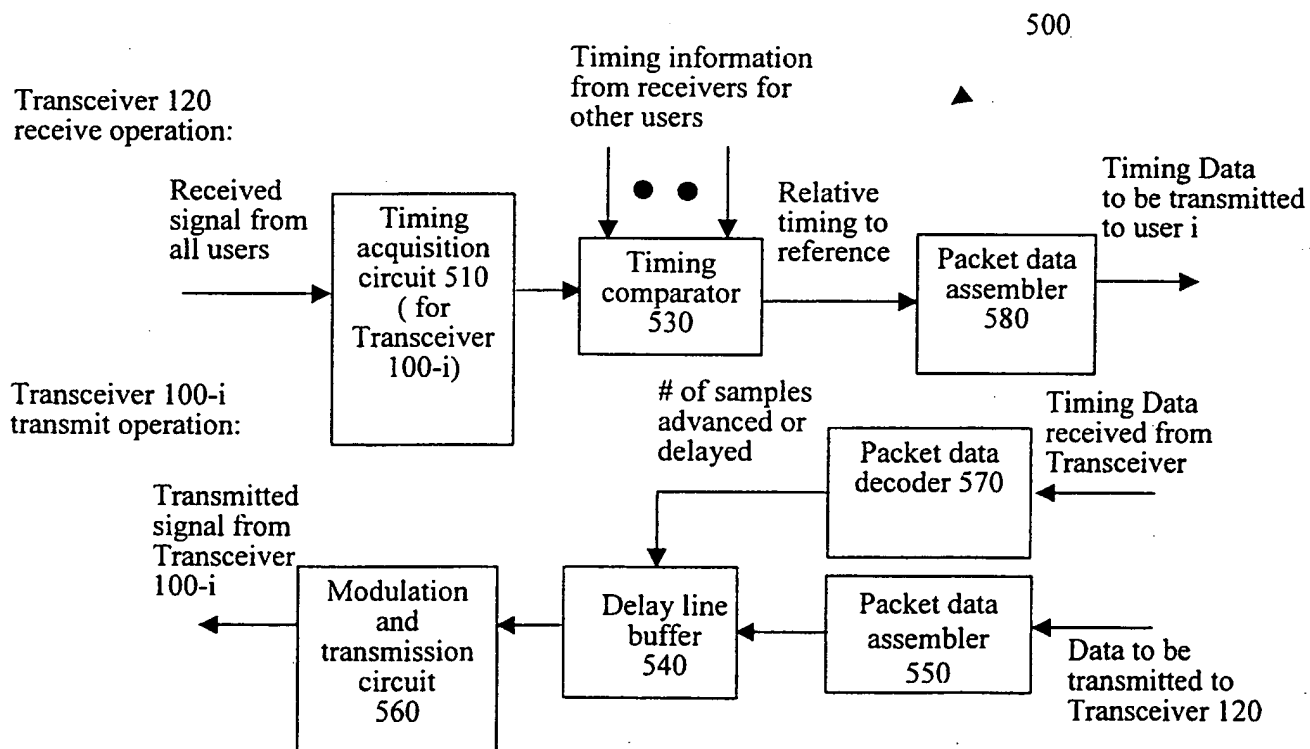


Figure 5

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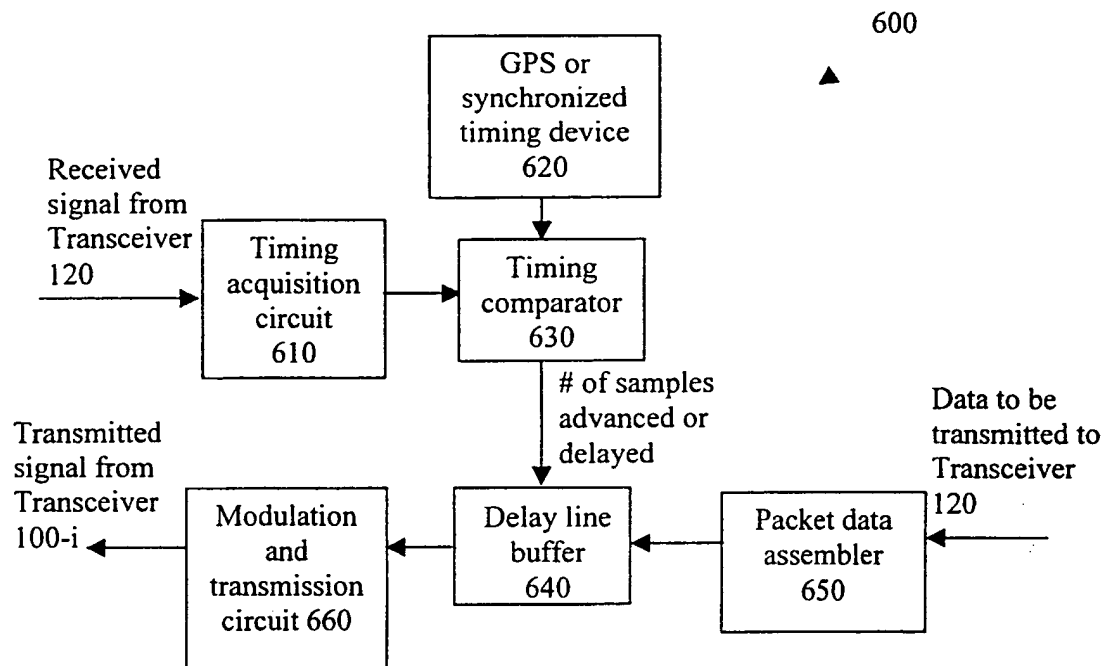


Figure 6

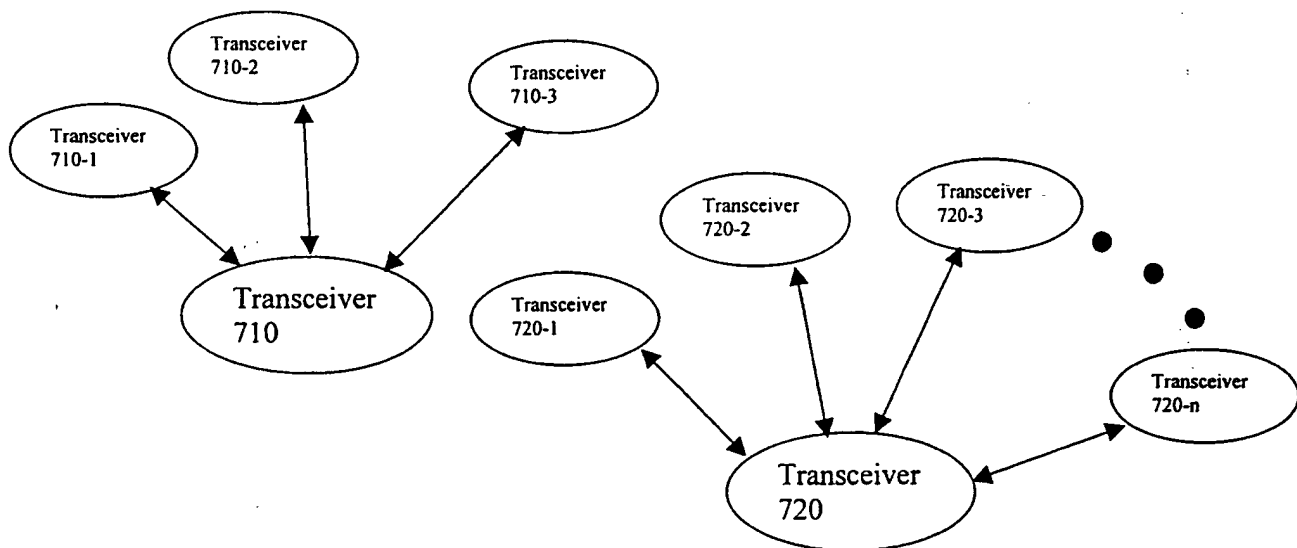


Figure 7

# INTERNATIONAL SEARCH REPORT

Internatic    Application No
PCT/US 00/41221

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7    H04B7/26

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
IPC 7    H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 499 236 A (GREENWOOD KENNETH C ET AL) 12 March 1996 (1996-03-12) column 2, line 17 - line 25 column 7, line 23 - line 55; claims 1-19 ---	1-49
X	GB 2 277 232 A (MOTOROLA INC) 19 October 1994 (1994-10-19) page 2, line 20 - line 27 page 3, line 1 - line 25; figure 1 ---	1-49
X	WO 99 49587 A (KONINKL PHILIPS ELECTRONICS NV ;PHILIPS SVENSKA AB (SE)) 30 September 1999 (1999-09-30) page 3, line 1 - line 22 page 7, line 1 -page 8, line 17 page 8, line 27 - line 30; figure 5 --- -/--	1-49

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

\* Special categories of cited documents :

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Date of the actual completion of the international search

20 March 2001

Date of mailing of the international search report

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# INTERNATIONAL SEARCH REPORT

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PCT/US 00/41221

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 870 427 A (TIEDEMANN JR EDWARD G ET AL) 9 February 1999 (1999-02-09) column 13, line 33 - line 61 -----	1-49